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विद्युतरोधन के लिए प्रयुक्त रेजिन आधारित अभिक्रियाशील यौगिक

भाग 2 परीक्षण पद्धतियाँ

(पहला पुनरीक्षण)

Indian Standard

RESIN BASED REACTIVE COMPOUNDS USED FOR ELECTRICAL INSULATION

PART 2 METHODS OF TEST

(*First Revision*)

ICS 17.220.99; 29.035.01

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

September 2005

Price Group 8

Solid Electrical Insulating Materials and Insulation Systems Sectional Committee, ET 02

NATIONAL FOREWORD

This Indian Standard (Part 2) (First Revision) which is identical with IEC 60455-2 (1998) 'Resin based reactive compounds used for electrical insulation — Part 2 : Methods of test' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendations of the Solid Electrical Insulating Materials and Insulation Systems Sectional Committee and approval of the Electrotechnical Division Council.

The text of the IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. In the adopted standard, certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Only the English text of the IEC Publication has been retained while adopting it as an Indian Standard and as such the page numbers given here are not same as in IEC publication.

This standard has been revised to align with the latest IEC Standard.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60050 (212) (1990) International Electrotechnical Vocabulary (IEV) — Chapter 212 : Insulating solids, liquids and gases	IS 1885 (Part 62) : 1993 Electrotechnical vocabulary: Part 62 Insulating solids, liquids and gases (*first revision*)	Identical
IEC 60068-2-10 (1988) Environmental testing — Part 2 : Tests. Test J and guidance: Mould growth	IS 9000 (Part 10) : 1979 Basic environmental testing procedures for electronic and electrical items : Part 10 Mould growth test	Technically equivalent
IEC 60112 (1979) Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions	IS 2824 : 1975 Method for determining the comparative tracking index of solid insulating materials under moist conditions (*first revision*)	do
IEC 60216-1 (1990) Guide for the determination of thermal endurance properties of electrical insulating materials — Part 1 : General guidelines for ageing procedures and evaluation of test results	IS 8504 (Part 1) : 1994 Guide for determination of thermal endurance properties of electrical insulating materials: Part 1 General guidelines for ageing procedures and evaluation of test results (*first revision*)	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60216-2 (1990) Guide for the determination of thermal endurance properties of electrical insulating materials — Part 2 : Choice of test criteria	IS 8504 (Part 2) : 1983 Guide for determination of thermal endurance properties of electrical insulating materials: Part 2 List of materials and available tests	Technically equivalent
IEC 60243-1 (1998) Electric strength of insulating materials — Test methods — Part 1 : Tests at power frequencies	IS 2584 : 1963 Method of test for electric strength of solid insulating materials at power frequencies	do
IEC 60250 (1969) Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths	IS 4486 : 1967 Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths	do
IEC 60426 (1973) Test methods for determining electrolytic corrosion with insulating materials	IS 8516 : 1977 Methods of test for determining electrolytic corrosion with insulating material	Identical
IEC 60455-1 (1998) Resin based reactive compounds used for electrical insulation — Part 1 : Definitions and general requirements	IS 13465 (Part 1) : 2005 Resin based reactive compounds used for electrical insulation: Part 1 Definitions and general requirements	do
IEC 60455-3-1 Resin based reactive compounds used for electrical insulation — Part 3 : Specifications for individual materials — Sheet 1 : Unfilled epoxy resinous compounds	IS 13465 (Part 3/Sec 1) : 1992 Solventless polymerisable resinous compounds used for electrical insulation: Part 3 Specifications for individual materials, Section 1 Unfilled epoxy resinous compounds	Technically equivalent
IEC 60455-3-2 Resin based reactive compounds used for electrical insulation — Part 3 : Specifications for individual materials — Sheet 2 : Quartz filled epoxy resinous compounds	IS 13465 (Part 3/Sec 2) : 1992 Solventless polymerisable resinous compounds used for electrical insulation: Part 3 Specifications for individual materials, Section 2 Quartz filled epoxy resinous compounds	do
IEC 60455-3-3 Resin based reactive compounds used for electrical insulation — Part 3 : Specifications for individual materials — Sheet 3 : Unfilled polyurethane compounds	IS 13465 (Part 3/Sec 3) : 1992 Solventless polymerisable resinous compounds used for electrical insulation: Part 3 Specifications for individual materials, Section 3 Unfilled polyurethane compounds	do
IEC 60455-3-4 Resin based reactive compounds used for electrical insulation — Part 3 : Specifications for individual materials — Sheet 4 : Filled polyurethane compounds	IS 13465 (Part 3/Sec 4) : 1992 Solventless polymerisable resinous compounds used for electrical insulation: Part 3 Specifications for individual materials, Section 4 Filled polyurethane compounds	do

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60707 (1991) Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source	IS 11731 (Part 2) : 1986 Methods of test for determination of flammability of solid electrical insulating materials when exposed to an igniting source: Part 2 Vertical specimen method	Technically equivalent
IEC 60814 (1997) Insulating liquids — Oil-impregnated paper and pressboard — Determination of water by automatic coulometric Karl Fischer titration	IS 13567 : 1992 Determination of water in insulating liquids and in oil-impregnated paper and pressboard by automatic coulometric Karl Fischer titration — Method of test	do
ISO 37 : 1994 Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties	IS 3400 (Part 1) : 1987 Methods of test for vulcanized rubbers: Part 1 Tensile stress-strain properties (*second revision*)	do
ISO 62 : 1980 Plastics — Determination of water absorption	IS 13360 (Part 8/Sec 1) : 1997 Plastics — Methods of testing: Part 8 Permanence/chemical properties, Section 1 Determination of water absorption	Identical
ISO 75-1 : 1993 Plastics — Determination of temperature of deflection under load — Part 1 : General test method	IS 13360 (Part 6/Sec 3) : 1997 Plastics — Methods of testing: Part 6 Thermal properties, Section 3 Determination of temperature of deflection under load — General test method	do
ISO 75-2 : 1993 Plastics — Determination of temperature of deflection under load — Part 2 : Plastics and ebonite	IS 13360 (Part 6/Sec 17) : 1997 Plastics — Methods of testing: Part 6 Thermal properties, Section 17 Determination of temperature of deflection under load — Plastics and ebonite	do
ISO 75-3 : 1993 Plastics — Determination of temperature of deflection under load — Part 3 : High strength thermosetting laminates and long fibre-reinforced plastics	IS 13360 (Part 6/Sec 18) : 1997 Plastics — Methods of testing: Part 6 Thermal properties, Section 18 Determination of temperature of deflection under load — High strength thermosetting laminates and long fibre-reinforced plastics	do
ISO 175 : 1981 Plastics — Determination of the effects of liquid chemicals, including water	IS 13360 (Part 8/Sec 3) : 1997 Plastics — Methods of testing: Part 8 Permanence/chemical properties, Section 3 Determination of the effects of liquid chemicals, including water	do

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 178 : 1983 Plastics — Determination of flexural properties	IS 13360 (Part 5/Sec 7) : 1996 Plastics — Methods of testing: Part 5 Mechanical properties, Section 7 Determination of flexural properties	Identical
ISO 179 : 1993 Plastics — Determination of charpy impact strength	IS 13360 (Part 5/Sec 5) : 1996 Plastics — Methods of testing: Part 5 Mechanical properties, Section 5 Determination of charpy impact strength	do
ISO 306 : 1994 Plastics — Thermoplastic materials — Determination of vicat softening temperature (VST)	IS 13360 (Part 6/Sec 1) : 1999 Plastics — Methods of testing : Part 6 Thermal properties, Section 1 Determination of vicat softening temperature of thermoplastic materials	do
ISO 527-1 : 1993 Plastics — Determination of tensile properties — Part 1 : General principles	IS 13360 (Part 5/Sec 1) : 1996 Plastics — Methods of testing: Part 5 Mechanical properties, Section 1 Determination of tensile properties — General principles	do
ISO 527-2 : 1993 Plastics — Determination of tensile properties — Part 2 : Test conditions for moulding and extrusion plastics	IS 13360 (Part 5/Sec 2) : 1996 Plastics — Methods of testing: Part 5 Mechanical properties, Section 2 Determination of tensile properties — Test conditions for moulding and extrusion plastics	do
ISO 527-5 : 1997 Plastics — Determination of tensile properties — Part 5 : Test conditions for unidirectional fibre-reinforced plastic composites	IS 13360 (Part 5/Sec 26) : 2004 Plastics — Methods of testing: Part 5 Mechanical properties, Section 26 Determination of tensile properties — Test conditions for unidirectional fibre-reinforced plastic composit	do
ISO 604 : 1993 Plastics — Determination of compressive properties	IS 13360 (Part 5/Sec 8) : 1996 Plastics — Methods of testing: Part 5 Mechanical properties, Section 8 Determination of compressive properties	do
ISO 868 : 1985 Plastics and ebonite — Determination of indentation hardness by means of a durometer (shore hardness)	IS 13360 (Part 5/Sec 11) : 1992 Plastics — Methods of testing : Part 5 Mechanical properties, Section 11 Determination of indentation hardness of plastics by means of durometer (shore hardness)	Technically equivalent

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 1183 : 1987 Plastics — Methods for determining the density and relative density of non-cellular plastics	IS 13360 (Part 3/Sec 4) : 1995 Plastics — Methods of testing: Part 3 Physical and dimensional properties, Section 4 Determination of bulk factor of moulding materials	Identical
ISO 1512 : 1974 Paints and varnishes — Sampling of products in liquid or paste form	IS 101 (Part 1/Sec 1) : 1986 Methods of sampling and test for paints, varnishes and related products: Part 1 Tests on liquid paints (general and physical), Section 1 Sampling	Technically equivalent
ISO 1513 : 1980 Paints and varnishes — Examination and preparation of samples for testing	IS 101 (Part 1/Sec 2) : 1987 Methods of sampling and test for paints, varnishes and related products: Part 1 Tests on liquid paints (general and physical), Section 2 Preliminary examination and preparation of samples for testing	do
ISO 1675 : 1985 Plastics — Liquid resins — Determination of density by the pyknometer method	IS 13360 (Part 3/Sec 7) : 1999 Plastics — Methods of testing: Part 3 Physical and dimensional properties, Section 7 Liquid resins — Determination of density by the pyknometer method	Identical
ISO 2039-1 : 1993 Plastics — Determination of hardness — Part 1 : Ball indentation method	IS 13360 (Part 5/Sec 12) : 1992 Plastics — Methods of testing: Part 5 Mechanical properties, Section 12 Determination of ball indentation hardness	Technically equivalent
ISO 2555 : 1989 Plastics — Resins in the liquid state or as emulsions of dispersions — Determination of apparent viscosity by the Brookfield test method	IS 13360 (Part 11/Sec 10) : 1999 Plastics — Methods of testing: Part 11 Special properties, Section 10 Resins in the liquid state or as emulsions or dispersions — Determination of apparent viscosity by the Brookfield test method	Identical
ISO 3451-1 : 1997 Plastics — Determination of ash — Part 1 : General methods	IS 13360 (Part 8/Sec 8) : 2004 Plastics — Methods of testing: Part 8 Permanence/chemical properties, Section 8 Determination of ash — General methods	do

The Technical Committee responsible for the preparation of this standard has reviewed the provisions of the following International Standards referred to in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60093 (1980)	Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials

International Standard	*Title*
IEC 60216-3-1 (1990)	Guide for the determination of thermal endurance properties of electrical insulating materials — Part 3 : Instruction for calculating thermal endurance characteristics — Section 1 : Calculations using mean values of normally distributed complete data
IEC 60216-3-2 (1993)	Guide for the determination of thermal endurance properties of electrical insulating materials — Part 3 : Instruction for calculating thermal endurance characteristics — Section 2 : Calculations for incomplete data : proof test results up to and including the median time to end-point (equal test groups)
IEC 60216-4-1 (1990)	Guide for the determination of thermal endurance properties of electrical insulating materials — Part 4 : Ageing ovens — Section 1 : Single-chamber ovens
IEC 60216-5 (1998)	Guide for the determination of thermal endurance properties of electrical insulating materials — Part 5 : Guidelines for application of thermal endurance characteristics
IEC 60296 (1982)	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60455-3-5	Resin based reactive compounds used for electrical insulation — Part 3 : Specifications for individual materials — Sheet 5 : Unsaturated polyester based impregnating resins
IEC 60455-3-11	Specification for solventless polymerisable resinous compounds used for electrical insulation — Part 3 : Specifications for individual materials — Sheet 11 : Epoxy resin-based coating powders
IEC 61006 (1991)	Methods of test for the determination of the glass transition temperature of electrical insulating materials
IEC 61033 (1991)	Methods of test for the determination of bond strength of impregnating agents to an enamelled wire substrate
IEC 61099 (1992)	Specifications for unused synthetic organic esters for electrical purposes
ISO 527 (all parts except Parts 1, 2 and 5)	Plastics — Determination of tensile properties
ISO 584 : 1982	Plastics — Unsaturated polyester resins — Determination of reactivity at 80 degrees C (conventional method)
ISO 1523 : 1983	Paints varnishes, petroleum and related products — Determination of flashpoint — Closed cup equilibrium method
ISO 2114 : 1996	Plastics — Unsaturated polyester resins — Determination of partial acid value and total acid value
ISO 2431 : 1993	Paints and varnishes — Determination of flow time by use of flow cups
ISO 2535 : 1997	Plastics — Unsaturated polyester resins — Measurement of gel time at 25 degrees C
ISO 2554 : 1997	Plastics — Unsaturated polyester resins — Determination of hydroxyl value

International Standard	*Title*
ISO 2592 : 1973	Petroleum products — Determination of flash and fire points — Cleveland open cup method
ISO 3001 : 1997	Plastics — Epoxide compounds — Determination of epoxide equivalent
ISO 3219 : 1993	Plastics — Polymers/resins in the liquid state or as emulsions or dispersions — Determination of viscosity using a rotational viscometer with defined shear rate
ISO 3521 : 1997	Plastics — Unsaturated polyester and epoxy resins — Determination of overall volume shrinkage
ISO 3679 : 1983	Paints, varnishes, petroleum and related products — Determination of flashpoint — Rapid equilibrium method
ISO 4573 : 1978	Plastics — Epoxide resins and glycidyl esters — Determination of inorganic chlorine
ISO 4583 : 1998	Plastics — Epoxide resins and related materials — Determination of easily saponifiable chlorine
ISO 4615 : 1979	Plastics — Unsaturated polyesters and epoxide resins — Determination of total chlorine content
ISO 4625 : 1980	Binders for paints and varnishes — Determination of softening point — Ring-and-ball method
ISO 7327 : 1994	Plastics — Hardeners and accelerators for epoxide resins — Determination of free acid in acid anhydride
ISO 9396 : 1997	Plastics — Phenolic resins — Determination of the gel time at a given temperature using automatic apparatus
ISO 9702 : 1998	Plastics — Amine epoxide hardeners — Determination of primary, secondary and tertiary amine group nitrogen content

For the purpose of deciding whether a particular requirement of this standard is complied with the final value observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RESIN BASED REACTIVE COMPOUNDS USED FOR ELECTRICAL INSULATION

PART 2 METHODS OF TEST

(First Revision)

1 Scope

This part of IEC 60455 specifies methods of test to be used for testing resin based reactive compounds, their components and cured compounds used for electrical insulation.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60455. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60455 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60050(212):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 212: Insulating solids, liquids and gases*

IEC 60068-2-10:1988, *Environmental testing – Part 2: Tests. Test J and guidance: Mould growth*

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60216-1:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 1: General guidelines for ageing procedures and evaluation of test results*

IEC 60216-2:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 2: Choice of test criteria*

IEC 60216-3-1:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 3: Instructions for calculating thermal endurance characteristics – Section 1: Calculations using mean values of normally distributed complete data*

IEC 60216-3-2:1993, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 3: Instructions for calculating thermal endurance characteristics – Section 2: Calculations for incomplete data: proof test results up to and including the median time to end-point (equal test groups)*

IEC/TR 60216-4-1:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 4: Ageing ovens – Section 1: Single-chamber ovens*

IEC 60216-5:1998, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 5: Guidelines for application of thermal endurance characteristics*

IEC 60243-1:1998, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60250:1969, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths*

IEC 60296:1982, *Specification for unused mineral insulating oils for transformers and switchgear*

IEC 60426:1973, *Test methods for determining electrolytic corrosion with insulating materials*

IEC 60455-1:1998, *Resin based reactive compounds used for electrical insulation – Part 1: Definitions and general requirements*

IEC 60455-3 (all parts), *Specification for solventless polymerisable resinous compounds used for electrical insulation – Part 3: Specifications for individual materials*

IEC 60707:1981, *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source*

IEC 60814:1997, *Insulating liquids – Oil-impregnated paper and pressboard – Determination of water by automatic coulometric Karl Fischer titration*

IEC 61006:1991, *Methods of test for the determination of the glass transition temperature of electrical insulating materials*

IEC 61033:1991, *Test methods for the determination of bond strength of impregnating agents to an enamelled wire substrate*

IEC 61099:1992, *Specifications for unused synthetic organic esters for electrical purposes*

ISO 37:1994, *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

ISO 62:1980, *Plastics – Determination of water absorption* 1)

ISO 75 (all parts), *Plastics and ebonite – Determination of temperature of deflection under load*

ISO 175:1981, *Plastics – Determination of the effects of liquid chemicals, including water*

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1) Revision to be published.

ISO 178:1993, *Plastics – Determination of flexural properties*

ISO 179:1993, *Plastics – Determination of Charpy impact strength* [1]

ISO 306:1994, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 584:1982, *Plastics – Unsaturated polyester resins – Determination of reactivity at 80 degrees C (conventional method)*

ISO 604:1993, *Plastics – Determination of compressive properties*

ISO 868:1985, *Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1183:1987, *Plastics – Methods for determining the density and relative density of non-cellular plastics*

ISO 1512:1991, *Paints and varnishes – Sampling of products in liquid or paste form*

ISO 1513:1992, *Paints and varnishes – Examination and preparation of samples for testing*

ISO 1523:1983, *Paints, varnishes, petroleum and related products – Determination of flashpoint – Closed cup equilibrium method*

ISO 1675:1985, *Plastics – Liquid resins – Determination of density by the pyknometer method*

ISO 2039-1:1993, *Plastics – Determination of hardness – Part 1: Ball indentation method*

ISO 2114:1996, *Plastics – Unsaturated polyester resins – Determination of partial acid value and total acid value*

ISO 2431:1993, *Paints and varnishes – Determination of flow time by use of flow cups*

ISO 2535:1997, *Plastics – Unsaturated polyester resins – Measurement of gel time at 25 degrees C*

ISO 2554:1997, *Plastics – Unsaturated polyester resins – Determination of hydroxyl value*

ISO 2555:1989, *Plastics – Resins in the liquid state or as emulsions or dispersions – Determination of apparent viscosity by the Brookfield test method*

ISO 2592:1973, *Petroleum products – Determination of flash and fire points – Cleveland open cup method* [1]

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[1] Revision to be published.

ISO 3001:1997, *Plastics – Epoxide compounds – Determination of epoxide equivalent*[1)]

ISO 3219:1993, *Plastics – Polymers/resins in the liquid state or as emulsions or dispersions – Determination of viscosity using a rotational viscometer with defined shear rate*

ISO 3451-1:1997, *Plastics – Determination of ash – Part 1: General methods*

ISO 3521:1997, *Plastics – Unsaturated polyester and epoxy resins – Determination of overall volume shrinkage*

ISO 3679:1983, *Paints, varnishes, petroleum and related products – Determination of flashpoint – Rapid equilibrium method*

ISO 4573:1978, *Plastics – Epoxide resins and glycidyl esters – Determination of inorganic chlorine*

ISO 4583:1998, *Plastics – Epoxide resins and related materials – Determination of easily saponifiable chlorine*

ISO 4615:1979, *Plastics – Unsaturated polyesters and epoxide resins – Determination of total chlorine content*

ISO 4625:1980, *Binders for paints and varnishes – Determination of softening point – Ring-and-ball method*

ISO 7327:1994, *Plastics – Hardeners and accelerators for epoxide resins – Determination of free acid in acid anhydride*

ISO 9396:1997, *Plastics – Phenolic resins – Determination of the gel time at a given temperature using automatic apparatus*

ISO 9702:1998, *Plastics – Amine epoxide hardeners – Determination of primary, secondary and tertiary amine group nitrogen content*

3 Definitions

For the purpose of this part of IEC 60455, the following definitions, as well as the definitions of IEC 60455-1 and IEC 60050(212), apply:

3.1
volume resistance
that part of the insulation resistance which is due to conduction through the volume and excluding surface current

3.2
volume resistivity
the volume resistance reduced to a cubical unit volume

3.3
dielectric dissipation factor (tan δ)
numerical value of the ratio of the imaginary to the real part of the complex permittivity

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1) Revision to be published.

3.4

relative permittivity (ε_r)

ratio of the absolute permittivity to the electric constant

NOTE – In practical engineering, it is usual to employ the term 'permittivity' when referring to relative permittivity.

4 General notes on methods of test

Unless otherwise specified in the relevant specification standard or in the method of test, all tests shall be carried out at atmospheric conditions in a temperature range of between 21 °C and 29 °C and a relative humidity range of between 45 % and 70 %. Before measurements are made, the sample or test specimen shall be pre-conditioned under these atmospheric conditions for a time sufficient to allow the sample or the test specimen to reach stability. For taking samples in liquid or paste form, ISO 1512 shall be applied. For preparation of such samples for testing, ISO 1513 shall be applied.

NOTE – For definitions of terms for standard atmospheres see ISO 558. The test atmosphere as specified above does not comply with any of the two standard atmospheres as specified in ISO 291 but covers both ranges inclusive of their tolerances.

Normally, all requirements for a method of test are given in the description, and diagrams are intended only to illustrate one possible arrangement for conducting the test. In case of inconsistencies between this standard and the specification sheets of IEC 60455-3 of this series, the latter shall prevail.

When another standard is invoked for a test method, reference to that standard shall be included in the report.

5 Methods of test for reactive compounds and their components

The materials before curing are resins (1), other reactive or non-reactive components (2) (for instance hardener, accelerator, stabilizer, filler), and the ready-to-use reactive compound (3). The numbers 1, 2 and/or 3 indicate the possible application of the methods of test described below.

5.1 Flash point (1, 2 and 3)

For flash point temperatures of 79 °C and above, the method given in ISO 2592 shall be used. For flash point temperatures below 79 °C, the method given in ISO 1523 shall be used with any of the closed-cup apparatus as described in annex A of that standard. ISO 1523 shall be read in conjunction with ISO 3679.

Two measurements shall be made on two separate samples, and the two results of flash point shall be reported along with reference to the standards applied.

5.2 Density (1, 2 and 3)

The method given in ISO 1675 shall be used. Two measurements shall be made, and the two results of density shall be reported.

5.3 Viscosity (1, 2 and 3)

The viscosity shall be determined with a suitable device at (23 ± 0,5) °C. If a rotating type of device is used, it shall be in accordance with ISO 2555 (Brookfield type) or with ISO 3219 (a type working at defined shear rate). If an efflux type of equipment is used, the method of test and the flow cup shall be in accordance with ISO 2431.

Two measurements shall be made, and the two results of viscosity shall be reported, along with reference to the standards applied.

5.4 Shelf life (1, 2 and 3)

The shelf life shall be determined by measurement of the change in a specified characteristic property after a certain storage time and temperature. Experience has shown that viscosity according to 5.3 and gel time according to 5.17 are appropriate characteristics. To assess shelf life, viscosity and/or gel time shall be determined according to 5.3 and/or 5.17 respectively, at a temperature and with an end-point as agreed upon between supplier and purchaser. Two measurements shall be made on both fresh material and on material stored for a time and at a temperature as agreed between supplier and purchaser. The two results of shelf life shall be reported, along with reference to the standards applied. The results shall contain the viscosity and/or the gel time before and after storing, the storing time and temperature and the test temperature.

5.5 Softening temperature (1 and 2)

The method given in ISO 306 or ISO 4625 shall be used. Two measurements shall be made, and the two results of softening temperature shall be reported along with reference to the standard applied.

5.6 Ash content (1 and 2)

The method given in ISO 3451-1, method A shall be used. Two measurements shall be made, and the two results of ash content shall be reported.

5.7 Filler content (1 and 2)

Method of test required, but not available.

5.8 Chlorine content

5.8.1 Total chlorine content of unsaturated polyesters and epoxide resins (1 and 2)

The method given in ISO 4615 shall be used. Two measurements shall be made, and the two results of total chlorine content shall be reported.

5.8.2 Inorganic chlorine content of epoxide resins and glycidyl esters (1)

The method given in ISO 4573 shall be used. Two measurements shall be made, and the two results of inorganic chlorine content shall be reported.

5.8.3 Easily saponifiable chlorine content of epoxide resins and related materials (1)

The method given in ISO 4583 shall be used. Two measurements shall be made, and the two results of saponifiable chlorine content shall be reported.

5.9 Epoxide equivalent of epoxide resins (1)

The method given in ISO 3001 shall be used. Two measurements shall be made, and the two results of epoxide equivalent shall be reported.

5.10 Water content (Karl Fischer method) (1 and 2)

The method given in IEC 60814 shall be used. Two measurements shall be made, and the two results of water content shall be reported.

5.11 Hydroxyl value

5.11.1 Polyester resins (1)

The method given in ISO 2554 shall be used. Two measurements shall be made, and the two results of hydroxyl value shall be reported.

5.11.2 Resins other than polyester (1)

Method of test required, but not available.

5.12 Acid value of polyester resins (1)

The method given in ISO 2114 shall be used. Two measurements shall be made, and the two results of acid value shall be reported.

5.13 Amount of double bonds of unsaturated polyester and acrylate resins (1)

Method of test required, but not available.

5.14 Acid and acid-anhydride content of acid-anhydride hardeners (2)

Method of test required, but not available.

5.15 Amine value (2)

Method of test required, but not available.

5.16 Pot life (3)

Pot life shall be determined by measurement of the change in a specified characteristic property after mixing. To assess pot life, viscosity and/or gel time shall be determined according to 5.3 and/or 5.17 respectively, at a temperature and with an end-point as agreed upon between supplier and purchaser. Two measurements shall be made, both on freshly prepared material and on material stored after preparation for a time and at a temperature as agreed between supplier and purchaser. The two results of pot life shall be reported along with reference to the standards applied. The report shall contain the viscosity and/or the gel time before and after storing, the storing time and temperature and the test temperature.

5.17 Gel time

5.17.1 Unsaturated polyester based compounds (3)

Gel time is the period of time after which the reactive compound reaches the gel state. The method given in ISO 2535 shall be used at a test temperature as agreed upon between supplier and purchaser. Two measurements shall be made, and the two results of gel time shall be reported along with the test temperature.

5.17.2 Phenolic resin based compounds (3)

The method given in ISO 9396 shall be used. Two measurements shall be made, and the two results of gel time shall be reported.

5.17.3 Other compounds (3)

Method of test required, but not available.

5.18 Exothermic temperature rise

5.18.1 Unsaturated polyester based compounds (3)

The method given in ISO 584 shall be used. Two measurements shall be made, and the two results of exothermic temperature rise shall be reported.

5.18.2 Compounds other than unsaturated polyester based (3)

Method of test required, but not available.

5.19 Total volume shrinkage of epoxide and unsaturated polyester based compounds (3)

The method given in ISO 3521 shall be used. Two measurements shall be made, and the two results of total volume shrinkage shall be reported. The report shall contain the test temperature, the density of the compound at test temperature, and the density of the specimen made of the cured compound.

6 Methods of test for cured reactive compounds

The cured compound is self-supporting and thus allows the preparation of rigid and flexible test specimens.

6.1 Test specimens

When the term "test specimen" is used it means solid parts of cured material in a shape as required for the method of test concerned. In the following text such "test specimens" are referred to as "specimens".

6.1.1 Preparation of the reactive compound

The reactive compound shall be a homogeneous mixture of such portions of the components as specified by the supplier. Also drying, de-aerating, heating and other measures to treat the components and the compound shall comply with the instructions given by the supplier. When compounds contain fillers, the possibility of settlement needs to be taken into account.

6.1.2 Preparation of test specimens

Specimens shall be prepared under conditions as specified in the particular method of test in the relevant specification sheet of IEC 60455-3, or as agreed upon between supplier and purchaser. This includes the casting process with respect to temperature and vacuum, the curing conditions with respect to temperature, and time or temperature-time programme, the removal from the mould and annealing and cooling.

Reactive compounds, which according to the instructions given by the supplier, cure at ambient temperature, generally reach the final state at ambient temperature only after days or weeks. To achieve a defined degree of cure in such conditions, the compounds shall be cured for 24 h at ambient temperature and immediately thereafter for 24 h at 80 °C, or as agreed between supplier and purchaser.

Specimens shall be cast in the proper shape according to the dimensions given in the method of test, or shall be prepared from cast pieces. They shall be free of voids, bubbles, nicks and scratches. During machining, excessive heating of the machined surfaces shall be avoided by cooling, for instance with water.

NOTE – Removal of the cured compound from the mould is facilitated by the use of release agents and moulds made of chromium-plated or other adequate material.

6.1.3 Type and number of test specimens

The type and number of specimens required for a particular method of test are specified in the method of test, in the relevant specification sheet of IEC 60455-3 or shall be agreed upon between supplier and purchaser.

6.2 Density

Method A or method B given in ISO 1183 shall be used. Two measurements shall be made. The kind of preparation and the dimensions of the specimen, the method used, and the two results of density shall be reported.

6.3 Mechanical properties

6.3.1 Tensile properties

6.3.1.1 Rigid material

The method given in ISO 527 shall be used with a speed of testing to break the specimen within (60 ± 15) s. The type of specimen shall be selected from ISO 527. Five specimens shall be tested. The kind of preparation, the dimensions and the type of the specimen, the speed of testing, and the five results of tensile properties shall be reported. As far as applicable, the report shall contain tensile stress at yield, at maximum load and at break, percentage elongation at yield and at break, and modulus of elasticity.

6.3.1.2 Flexible material

The method given in ISO 37 shall be used for a dumb-bell specimen. Five specimens shall be tested. The kind of preparation and the type of dumb-bell specimen, and the five results of tensile properties shall be reported. The report shall contain tensile strength, percentage elongation at break, and modulus of elasticity.

6.3.2 Compressive properties

The method given in ISO 604 shall be used. Five specimens shall be tested. The kind of preparation and the dimensions of the specimen, the rate of deformation, and the five results of compressive properties shall be reported. As far as applicable, the report shall contain compressive strength at maximum load, compressive yield stress, and percentage compressive strain at rupture.

6.3.3 Flexural properties

The method given in ISO 178 shall be used with a relative rate of movement of the loading nose and the supports, so that the specimen ruptures or reaches the maximum load within (60 ± 15) s. Five specimens shall be tested. The kind of preparation and the dimensions of the specimen, the relative rate of movement, and the five results of flexural properties shall be reported. As far as applicable, the report shall contain the flexural stress at rupture or at maximum load, the corresponding deflection, and the modulus of elasticity.

6.3.4 Impact strength

6.3.4.1 Unnotched specimens

The method given in ISO 179 shall be used. Ten specimens shall be tested. The kind of preparation, the dimensions and the type of specimen, as well as the 10 results of impact strength shall be reported.

6.3.4.2 Notched specimens

The method given in ISO 179 shall be used with a notched specimen. Ten specimens shall be tested. The kind of preparation, the dimensions and type of specimen as well as the 10 results of impact strength shall be reported.

6.3.5 Hardness

6.3.5.1 Rigid material

The method given in ISO 2039-1 (ball indentation method); or the method given in ISO 868 (Shore D hardness) shall be used. Five measurements shall be made on one or more specimens. The kind of preparation and the dimensions of the specimen, the test load applied, and the five results of hardness shall be reported.

6.3.5.2 Flexible material

The method given in ISO 868 (preferably Shore A hardness) shall be used. Five measurements shall be made on one or more specimens. The kind of preparation, and the dimensions of the specimen, the type of durometer (A or D) used, and the five results of indentation hardness shall be reported.

6.4 Thermal properties

6.4.1 Bond strength at elevated temperature

The twisted coil test, method A, or the helical coil test, method B, given in IEC 61033, shall be used. The test temperature shall be in accordance with the relevant specification sheet of IEC 60455-3, or shall be agreed upon between supplier and purchaser. Five specimens shall be tested. The method, the type of enamelled winding wire used as substrate, and the five results shall be reported.

6.4.2 Linear thermal expansion

Method of test required, but not available.

6.4.3 Thermal conductivity

Method of test required, but not available.

6.4.4 Glass transition

6.4.4.1 Glass transition temperature

One of the methods given in IEC 61006 shall be used. Two measurements shall be made. The kind of preparation and, if applicable, the dimensions of the specimen, the method used (A: DSC or DTA, B1: TMA, expansion mode, or B2: TMA, penetration mode), and the two results of glass transition temperature shall be reported.

6.4.4.2 Temperature of deflection under load

Method A or method B given in ISO 75 shall be used. Two specimens shall be tested. The kind of preparation and the dimensions of the specimen, the method used, and the two results of temperature of deflection under load shall be reported.

NOTE – The temperature of deflection under load is of the same nature as the glass transition temperature, but the methods given in ISO 75 do not allow temperatures below 40 °C to be determined. It is therefore recommended to apply preferably the methods according to 6.4.4.1.

6.4.5 Flammability

The methods FH and FV given in IEC 60707 shall be used. For each method five specimens shall be tested. Method FH shall be applied only in the case that the result according to method FV is worse than category FV 2. The kind of preparation and the dimensions of the test specimen, as well as the result of flammability obtained with method FV and, if applicable, with method FH, shall be reported.

6.4.6 Thermal shock

Method of test required, but not available.

6.4.7 Temperature index

NOTE – The temperature index depends on the choice of test criterion and of the end-point criterion. Therefore, for one and the same material, results for the temperature index may vary by 80 K or more.

6.4.7.1 Procedure

The method given in IEC 60216 shall be used. The test and end-point criteria shall be in accordance with the relevant specification sheet of IEC 60455-3, or shall be agreed upon between supplier and purchaser. Two test criteria shall be used. For each test criterion at least three exposure temperatures shall be applied. The difference between two subsequent exposure temperatures shall not exceed 20 K. If the correlation coefficient is less than 0,95, one more set of specimens shall be tested at an exposure temperature different from the temperature originally chosen.

NOTE – ISO 2578 is based on the principles laid down in IEC 60216. By deleting all information that is not required for planning and running a temperature index experiment and for calculation of results, ISO 2578 has become a practical short version as required for use in a laboratory.

6.4.7.2 Result

For each test criterion, the kind of preparation and the type and dimensions of the specimen, the number of specimens for each test, the exposure temperatures, and the results shall be reported along with reference to the standards applied. The results for each test set shall contain the specimen end-point times, the time to end-point for each exposure temperature, a graph showing the property values as a function of the logarithm of the times to end-point, the thermal endurance graph (first order regression line) on thermal endurance graph paper, the temperature index, and the correlation coefficient.

6.5 Chemical properties

6.5.1 Water absorption

Method 1 (water at 23 °C) and method 3 (boiling water) given in ISO 62 shall be used. For each method three specimens shall be tested. The kind of preparation and the dimensions of the specimen, and the three results of water absorption obtained with each of method 1 and method 3 shall be reported. One untreated specimen shall be kept for reference.

6.5.2 Effect of liquid chemicals

The method given in ISO 175 shall be used. Unless otherwise specified, the temperature of the test liquid shall be (23 ± 2) °C and the immersion time shall be (168 ± 1) h (seven days). For each test liquid three specimens shall be tested. The kind of preparation and the dimensions of the specimen, the type of test liquid and the three results for each of the test liquids shall be reported. For each test liquid the result shall contain the change of appearance, dimensions and mass for each of the three specimens. One untreated specimen shall be kept for reference.

6.5.3 Resistance to mould growth

The method given in IEC 60068-2-10 shall be used. Three specimens according to 6.6.1.2 below shall be tested, and the three results of resistance to mould growth shall be reported. One untreated specimen shall be kept for reference.

6.5.4 Water vapour permeability

Method of test required, but not available.

6.6 Electrical properties

6.6.1 Effect of water immersion on volume resistivity

The method given in IEC 60093 shall be used. If IEC 60093 is not applicable for the material under test, then the following method may be used.

6.6.1.1 Equipment

The following equipment shall be used:

- any commercially available tera-ohmmeter with an accuracy of ±10 %;
- metal cylinder to be used as voltage electrode (top electrode) of at least 60 mm diameter having a mass to provide a pressure on the specimen of about 0,015 MPa;
- two conducting rubber disks having the same diameter as the top electrode and of 3 mm to 5 mm thickness with a maximum resistance of 1 000 Ω, and with a shore A hardness of 65 to 85;
- metal cylinder having the same diameter as the top electrode and of about 70 mm height (bottom electrode).

6.6.1.2 Test specimen

The specimen shall be in the form of a disk or a square with a diameter or an edge length exceeding the diameter of the top electrode by at least 10 mm. The thickness shall not exceed 3 mm and the flat surfaces shall be in parallel. Three specimens shall be prepared.

NOTE – The specimen may be cast between plates, with a wound piece of enamelled round winding wire used as a spacer.

6.6.1.3 Procedure

The test set-up shall consist of the specimen placed between the two metal cylinders with the rubber disks as intervening layers. For an example of the complete test arrangement see figure 1. The d.c. test voltage shall be adjusted to provide an electrical field strength of not more than 1 000 V/mm. The specimen shall be tested before and after immersion in demineralized water. Unless otherwise specified, the temperature of the water shall be (23 ± 2) °C and the time of immersion shall be (168 ± 1) h (seven days).

After immersion in water the test set-up shall be made immediately after removing the specimen from the water and blotting it between filter papers to remove excessive water. The resistance measurement shall be taken (15 ± 1) min after the test set-up is made. The reading shall be taken (60 ± 5) s after electrification.

In the case where, for example, the diameter of the top electrode is 60 mm, resistivity shall be calculated as:

$$\rho = (2{,}83 \times R)/d$$

where

ρ is the resistivity (Ωm);

d is the specimen thickness (mm);

R is the measured resistance (Ω).

For a different diameter D of the top electrode, replace the factor 2,83 by:

$$2{,}83D^2 / 3\,600 \text{ with } D \text{ in millimetres.}$$

6.6.1.4 Result

Three specimens shall be tested and the kind of preparation, the diameter of the electrodes, the dimensions of the test specimen, the test voltage used, and the three results before and after immersion in water shall be reported, along with reference to the standard applied. The results shall contain volume resistance and volume resistivity.

6.6.2 Dielectric dissipation factor (tan δ) and relative permittivity (ε_r)

The method given in IEC 60250 shall be used. If IEC 60250 is not applicable for the material under test, then the following method may be used.

6.6.2.1 Equipment

Any commercially available and adequate impedance-meter may be used, indicating the dielectric dissipation factor (tan δ) and the relative permittivity (ε_r).

6.6.2.2 Test specimen

A test specimen in accordance with 6.6.1.2 shall be used.

6.6.2.3 Procedure

The top electrode shall have a diameter of at least 40 mm and may or may not be surrounded by a shield electrode. The bottom electrode shall have a diameter exceeding the diameter of the top electrode by at least 20 mm and shall be applied concentrically to the upper electrode.

The electrodes shall be provided by brushing a conductive dispersion such as graphite or silver, or by applying a metal foil of a thickness of not more than 0,005 mm, made to adhere with a drop of oil, or by any other equally suitable procedure.

Unless otherwise specified, the test shall be carried out at (23 ± 2) °C with a sinusoidal test voltage at a frequency of 1 kHz. The connections to the specimen shall be in accordance with the instruction manual of the testing device.

6.6.2.4 Result

Two specimens shall be tested. The kind of preparation and the dimensions of the test specimen, the test temperature, the electrodes employed, the test voltage and frequency used, and the two results shall be reported along with reference to the standard applied. The report shall contain the dielectric dissipation factor and the relative permittivity.

6.6.3 Breakdown voltage and electric strength

Breakdown voltage shall be measured by using IEC 60243-1. If IEC 60243-1 is not applicable to the material under test, clauses 4 and 6 may be amended as below.

6.6.3.1 Electrodes

The electrode arrangement shall be the ball-to-plate type. The high-voltage electrode shall consist of a polished steel ball with a radius of (3 ± 0,0005) mm for rigid material, and (10 ± 0,0005) mm for flexible material. Polished steel balls with a surface roughness of less than 0,001 mm as used in ball bearings (class III) are easily available and have been found adequate for the purpose. The earth electrode shall be a plate with a diameter of (75 ± 1) mm and with rounded edge of a radius of (3 ± 0,1) mm. For the complete test arrangement for flexible material, see figure 2. In the case of rigid material, the upper electrode and the specimen shall be as shown in figure 3.

NOTE 1 – The ball-to-plate electrode arrangement gives, compared to a plate-to-plate set, a slightly increased field strength depending on the radius of the ball electrode and the thickness of the specimen.

EXAMPLE – For a radius of 10 mm and a thickness of 0,1 mm, the increase in field strength compared to that of plate-to-plate arrangement is about 10 %.

NOTE 2 – If a round cylindrical glass container of sufficient size is used to accommodate the test set-up and the fluid with the earth electrode at the bottom of it, such a container makes it possible to observe visually the process when the voltage is applied. It also permits the earth connection and the fluid supply through the bottom electrode, with a fluid overflow at the top of the container, see figure 2. If an elevated test temperature is required, such an arrangement allows the fluid to be used for heating purposes.

6.6.3.2 Test specimen

The thickness of that part of the specimen which is subject to breakdown shall not exceed 1 mm. The thickness of any two of the specimens of one set shall not vary by more than 10 %.

NOTE – It is generally found that the electric strength for cured reactive compounds with a glass transition temperature above 80 °C is from 50 kV/mm to 100 kV/mm and can be even more, for instance, for hot curing cycloaliphatic epoxide based compounds. Consequently, testing specimens of a thickness of significantly more than 1 mm and with an electrode arrangement of, for instance, 25/75 mm as specified in IEC 60243-1, may require voltage levels above 200 kV. This may lead to conditions where flashover or partial flashover with subsequent breakdown outside the electrode area cannot be avoided.

6.6.3.2.1 Rigid material

The specimen shall form a cylindrical rod of cast compound with a diameter of about 30 mm and with a length, in millimetres, twice the assumed numerical value of breakdown voltage in kilovolts. This rod shall contain a central lead wire with a steel ball attached to it at one end and apart from the other end completely embedded in the casting compound.

After the mould is removed, that end of the specimen which is close to the ball electrode, shall be ground to the specified thickness, then polished and coated with a conductive layer, for instance a dispersion of graphite or silver, which serves as the earth electrode. During grinding the thickness shall be controlled by means of a permeameter type device calibrated in thickness. For an example of the specimen set-up, see figure 3. This set-up can be accommodated in a glass container as in figure 2.

NOTE – For casting, a glass tube may serve as a mould with the lead wire and the ball electrode properly centred by adequate means. A piece of welding wire of, for instance, 3 mm diameter may serve as a lead wire, with one end soldered to the ball electrode.

After testing, the cured compound is removed at the point of breakdown to allow measurement of the space between the polished surface and the ball electrode. The space shall be measured by means of a micrometer probe, and reported as thickness.

6.6.3.2.2 Flexible material

A specimen in accordance with 6.6.1.2 shall be used.

6.6.3.3 Procedure

The rate of increase of voltage shall be not more than 500 V/s. Unless otherwise specified, the test temperature shall be (23 ± 2) °C. The test shall be carried out with the specimen and the electrodes in a dielectric fluid, which is circulated and maintained at the specified test temperature. Unless otherwise specified, unused mineral insulating oil according to IEC 60296, or unused synthetic organic ester according to IEC 61099 shall be employed.

6.6.3.4 Result

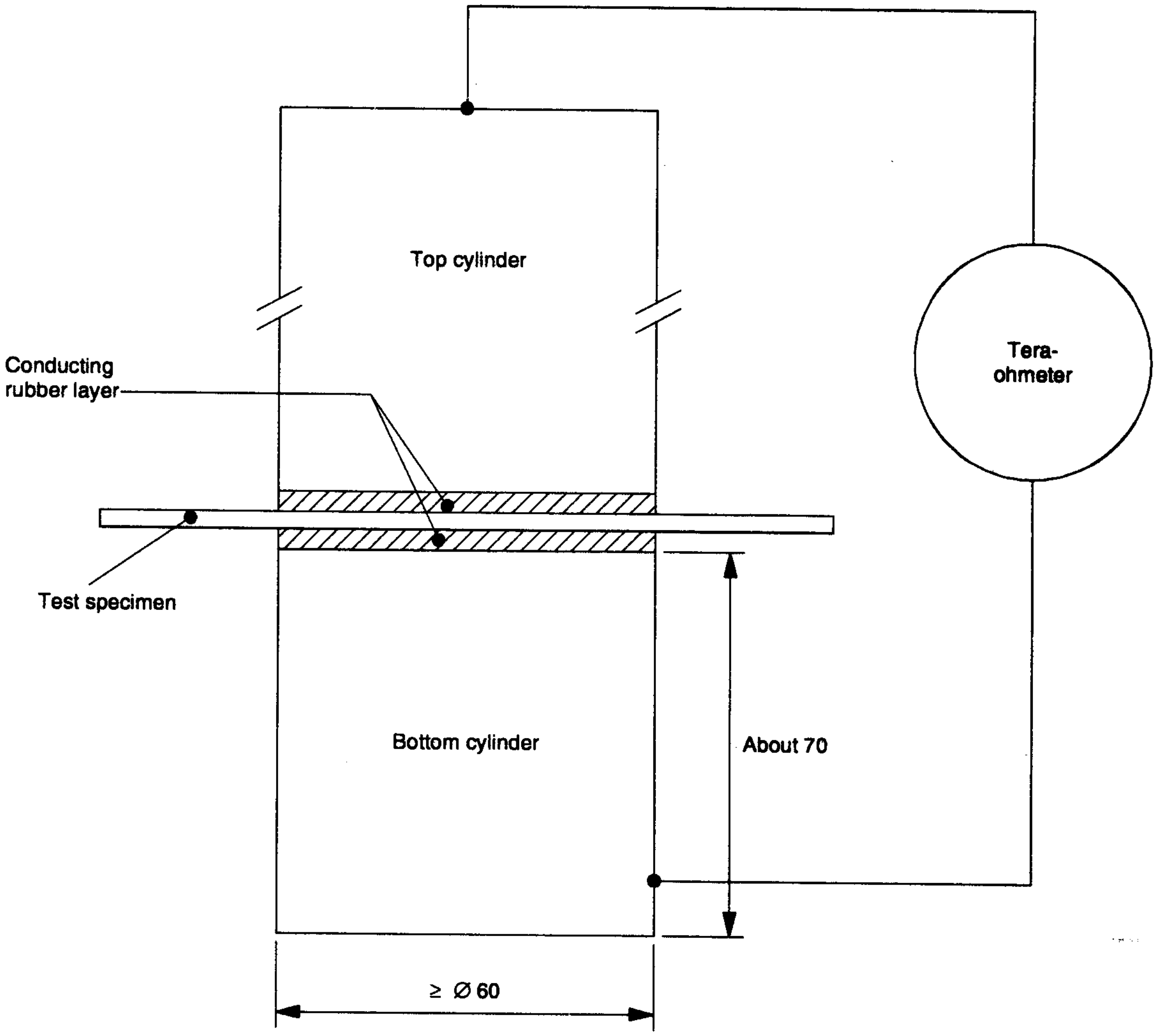
Five specimens shall be tested. The type and method of preparation of the specimen and its dimensions, the test temperature, the radius of the ball electrode, the type of dielectric fluid used and the five results shall be reported, along with reference to the standards applied. The results shall contain the thickness of the specimen at the point of breakdown, the breakdown voltage and the electric strength.

6.6.4 Proof tracking index (PTI)

The method given in 6.3 of IEC 60112 shall be used. Three specimens shall be tested with a proof voltage as specified in the relevant specification sheet, or as agreed upon between supplier and purchaser. The kind of preparation and the dimensions of the specimen, as well as the three results of PTI, shall be reported. The results shall contain the proof voltage applied and the number of drops obtained.

6.6.5 Electrolytic corrosion

The visual method given in IEC 60426 shall be used. Three specimens shall be tested. The three results of electrolytic corrosion shall be reported.



Dimensions in millimetres

Figure 1 – Test set-up for volume resistivity

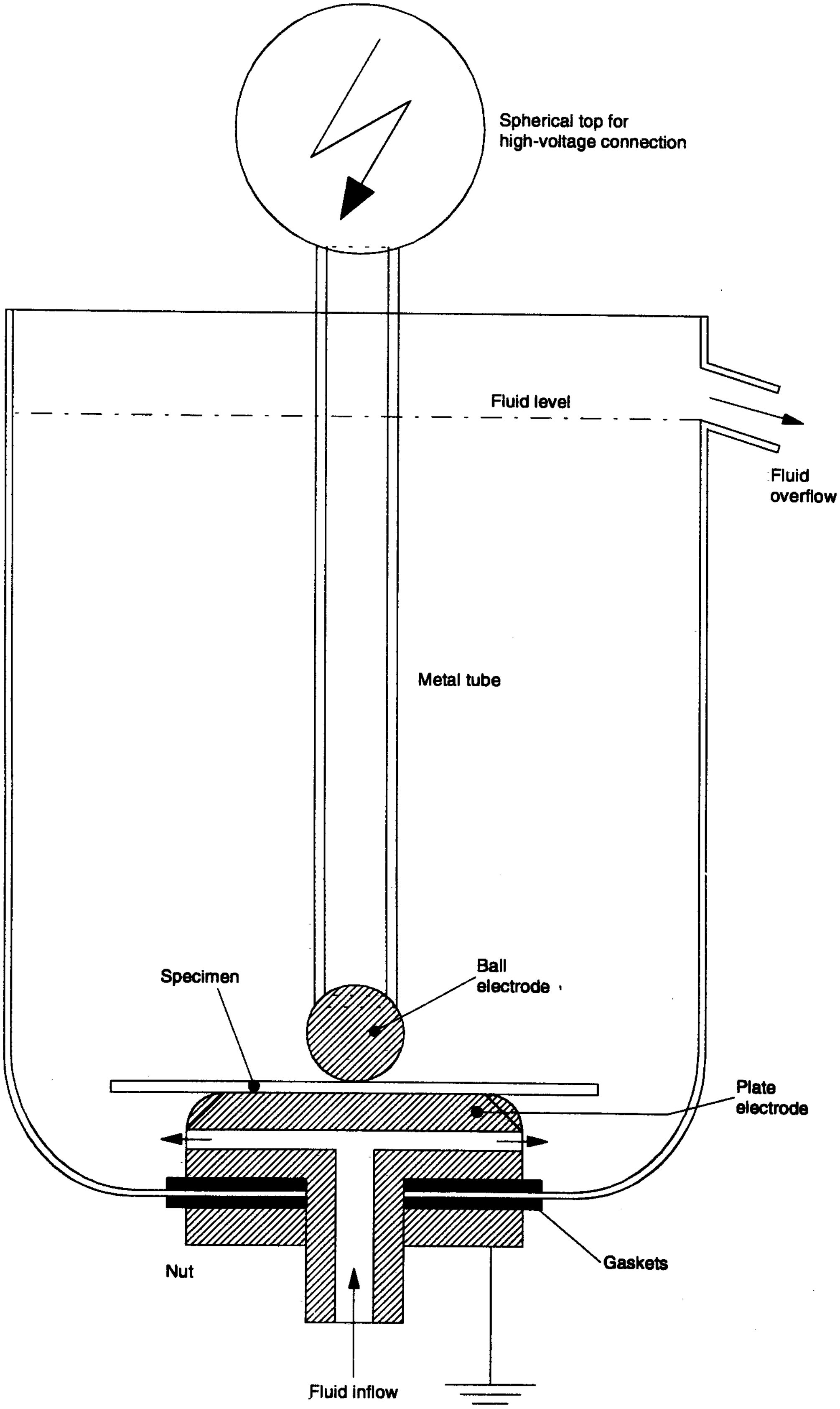


Figure 2 – Example of electrode arrangement for flexible cured compound

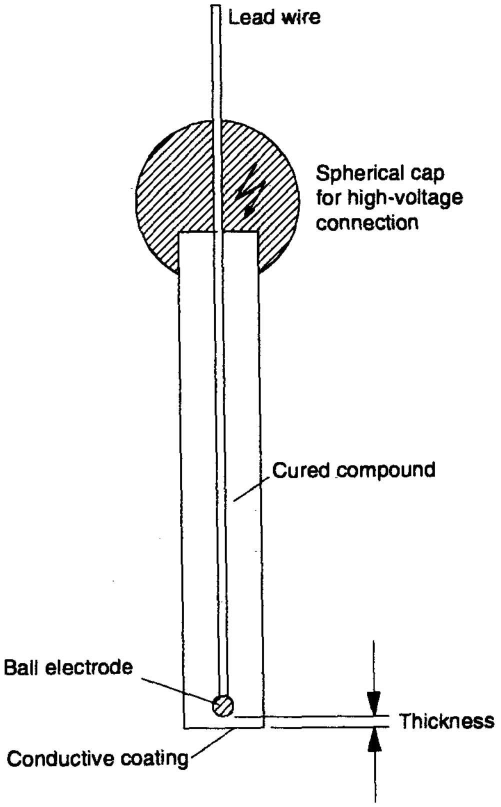


Figure 3 – Example of electrode arrangement for rigid cured compound

Annex A
(informative)

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